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IMPLEMENTATION OF INSTRUCTIONAL STRATEGIES FOR DECISION-MAKING TRAINING

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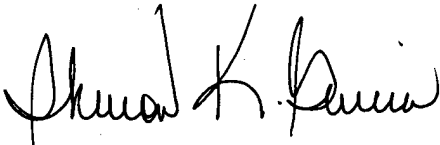
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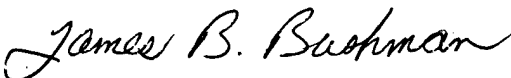
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13. ABSTRACT (Maximum 200 words) This paper documents work performed to develop a computer-based training prototype to teach decision-making skills to personnel in Logistics Command and Control domain. In particular, this paper discusses how the instructional strategies developed for training decision-making skills were implemented within the prototype. Focus is also given to problems encountered when trying to simulate "real" world problems in an artificial environment and how these were addressed.				
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PREFACE

This paper documents work performed during Phase 2 of a three-phase project entitled, "Desktop Decision Training for Logistics Command and Control (DDT/LC²).” This project is being accomplished under Contract No. F33615-91-C-0007, with Systems Engineering Associates (SEA), San Diego, CA. Management of this effort is provided by the Armstrong Laboratory, Human Resources Directorate, Technical Training Research Division, Instructional Systems Branch (AL/HRTD).

This project is being accomplished in three phases. Phase 1 was devoted to developing a theory-based instructional strategy and a PC-based software system architecture (Brecke & Garcia, 1995). Phase 2 focused on developing an initial training prototype. Phase 3 is oriented toward further development of the prototype into a deployable training system that can also serve as a research vehicle for exploring instructional strategy variations.

This paper describes work performed during Phase 2 to develop the initial decision-making training prototype. It is described from the viewpoint of instructional design and documents some of the significant and interesting problems that had to be resolved. A companion report (Van de Wetering & Garcia, 1995, in press) describes the prototype from the software engineering perspective.

SUMMARY

In May 1989, the Air Force Logistics Plans and Programs Directorate (HQ USAF/LGX) requested that the Air Force Human Resources Directorate (HR) develop an improved training technology for Logistics Command and Control Centers through the United States Air Force (USAF). The objective was to provide a means of training logistics decision makers to work with critical information and achieve the best use of resources. This tasking originated under a Memorandum of Agreement between HQ USAF/LGX, Air Force Systems Command (now the Air Force Material Command), and HR.

In response, HR let a contract with Systems Engineering Associates (SEA) to produce a desktop decision trainer which will provide individual instruction and enable students to practice solving realistic logistics problems in a Logistics Readiness Center environment. The project, which began in February 1992, will be completed in February 1997.

I. INTRODUCTION

The objectives of the "Desktop Decision Training for Logistics Command and Control (DDT/LC²)" research and development effort are to: (1) identify and develop instructional strategies for training decision-making skills; (2) identify and develop decision-making models to serve as a basis for training; and (3) develop an experimental computer-based training prototype that combines decision-making lessons with a simulation environment to enable logistics personnel to experience similar problems and situations encountered in the operational environment. The prototype will enable students to practice decision-making skills and obtain feedback relative to their performance.

This project is being accomplished in three phases. Phase 1 was devoted to developing a theory-based instructional strategy and PC-based software system architecture (Brecke & Garcia, 1995). Phase 2 focused on developing an initial training prototype. Phase 3 is oriented toward further development of the prototype into a deployable training system that can also serve as a research vehicle for exploring instructional strategy variations.

This paper describes work performed during Phase 2 to develop the initial decision-making training prototype. It is described from the viewpoint of instructional design and documents some of the problems that needed to be resolved. A companion report (Van de Wetering & Garcia, 1995, in press) describes the prototype from the software engineering perspective.

II. PHASE 2 PROTOTYPE INSTRUCTIONAL STRATEGY

The Phase 2 prototype (also referred to as DDT Beta Version 0.1), can be illustrated by two complementary views of the overall system design. The first view represents the DDT/LC² system as an instructional strategy (Figure 1). The second views the system as a system "architecture" of software components (Figure 2).

Figure 1. Multi-level instructional strategy.

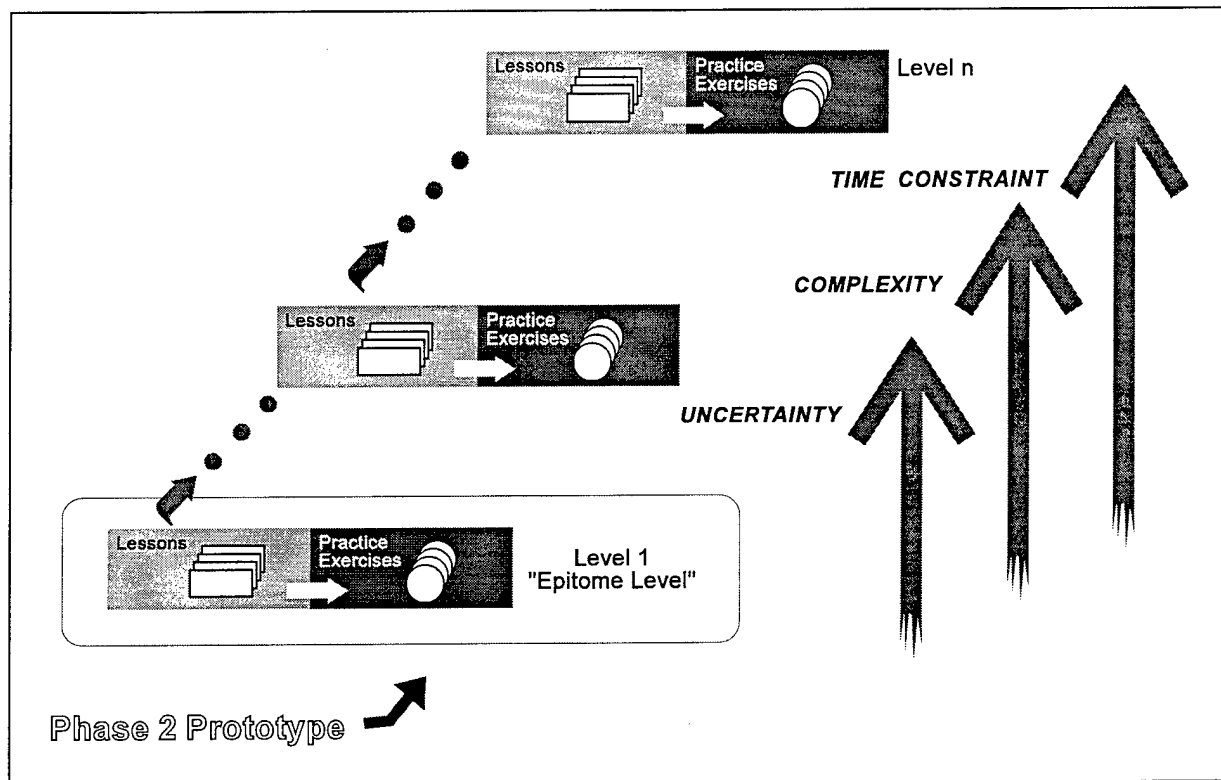


Figure 1 represents a macro-view of the instructional strategy for the desktop decision trainer. A "course" of instruction leading to the desired training outcome is subdivided into levels of elaboration (Reigeluth, 1983). The first level is the "epitome" level, at which the student is exposed to the simplest possible form of decision making in a chosen domain. For purposes of this project, the domain is Air Force Logistics Supply. At subsequent levels, the student experiences increasingly elaborate decision making situations until some predetermined target level of complexity is reached.

Each level contains two different forms of instruction -- lessons and exercises. Lessons precede exercises and are designed as standard Computer Assisted Instruction (CAI) to foster the

acquisition of declarative knowledge about how variables in the decision making situation influence decision goals and options. Following the lessons, the student is subjected to instruction in the form of simulation exercises. This form of instruction no longer provides well ordered and carefully structured presentations with content, examples, explanations, and practice, but immerses the student in a realistic scenario in which they must make decisions without further guidance. These "exercises" are designed to foster the development of the recognition-primed decision mode (Klein and Calderwood, 1990). Once the student achieves a specified level of reliability in that mode, they proceed to the next level. At present, The DDT Beta Version 0.1 includes lessons and exercises for the "epitome" level.

Figure 2. System architecture.

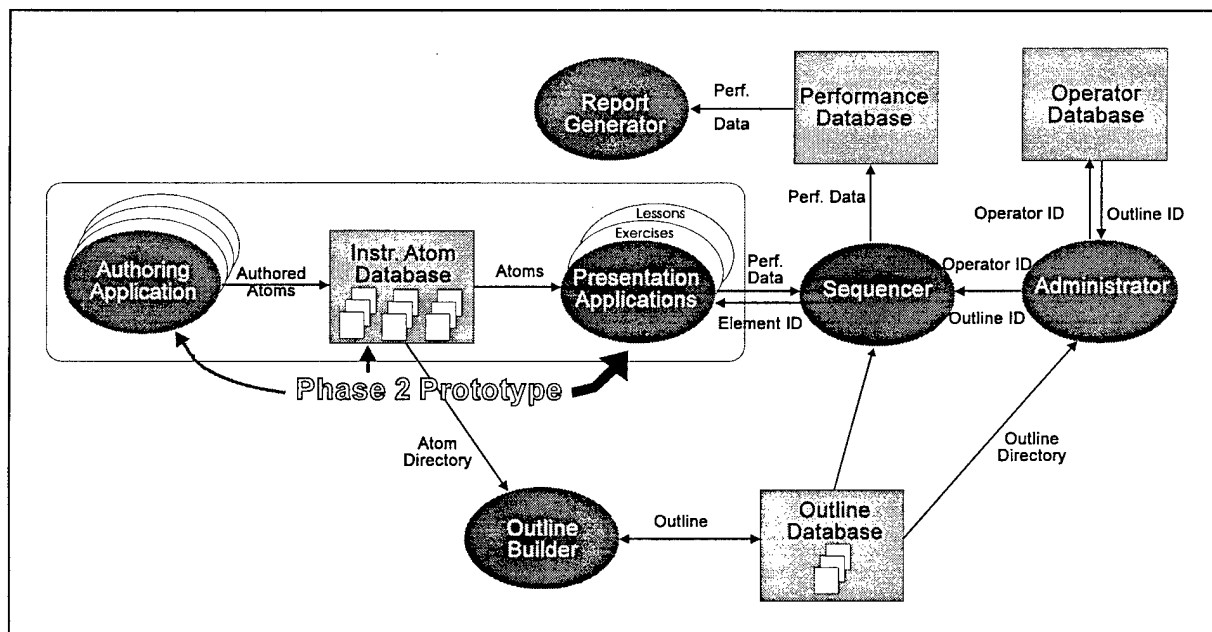


Figure 2 illustrates the software architecture used to implement lessons and exercises. "Ovals" represent processes and programs in this diagram, while "boxes" represent databases. The system's instructional atom database includes all of its instructional content. This database is made up of instructional atoms, which are individual lessons and exercises. As suggested in Figure 2, instructional atoms are created by authoring applications and isplayed by presentation applications. This architecture introduces minimal constraints upon the content of lessons and exercises (instructional atoms). It permits any kind of instruction to be used, provided the instruction is accompanied by an authoring program and a presentation program.

The outline database contains instructional strategies for courses. Each strategy identifies the instructional atoms that will be presented in a course and constrains their presentation. For example, an instructional strategy that includes minimum learner control may dictate a strict presentation sequence for a course's atoms, while a strategy that provides maximum learner control may remove all constraints upon the sequence of atom presentation. The DDT's instructional atom database and its course outline database separate the system's instructional content from instructional strategy.

Course outlines are produced by an outline builder and are executed by the system's sequencer. The outline builder resembles an authoring application, but instead of enabling the production of instructional atoms, it enables production of course outlines. The DDT's sequencer is responsible for invoking presentation applications (and thus displaying instructional atoms) in accordance with a course outline. Information regarding a learner's performance is recorded by the sequencer in the DDT's performance database. The system's report generator organizes performance data for display and printing.

The DDT's final database, the operator database, identifies operators and classifies them as learners, instructors, authors, or researchers. It also associates each operator with a course and a strategy. The system's administrator process manages this database and provides the system's login services.

III. Instructional Strategy Implementation

This section describes how the lessons and the exercises were implemented. The starting point for the implementation was an exercise scenario developed in Phase 1, with the aid of LC² subject matter experts (SMEs). We begin our account of instructional strategy implementation with the lessons and then turn to the exercises.

3.1. LESSON IMPLEMENTATION

3.1.1. Lesson Design and Development

Two lessons providing the essential knowledge required for playing the exercise scenario were developed. The process involved the four steps of topic determination, syllabus layout, lesson specification, and lesson development. Required lesson topics were determined by considering the logical prerequisites for a basic understanding of the system and the artificial world used in the exercise. The topics were assigned to lessons and sections within lessons, with five sections in the first and seven sections in the second lesson. The sequence of sections was again determined on the basis of logical prerequisite considerations. Detailed specifications for each section in each lesson were then written. These specifications contained the exact text and ideas for: (a) illustrations; and (b) instructional elements planned for each section.

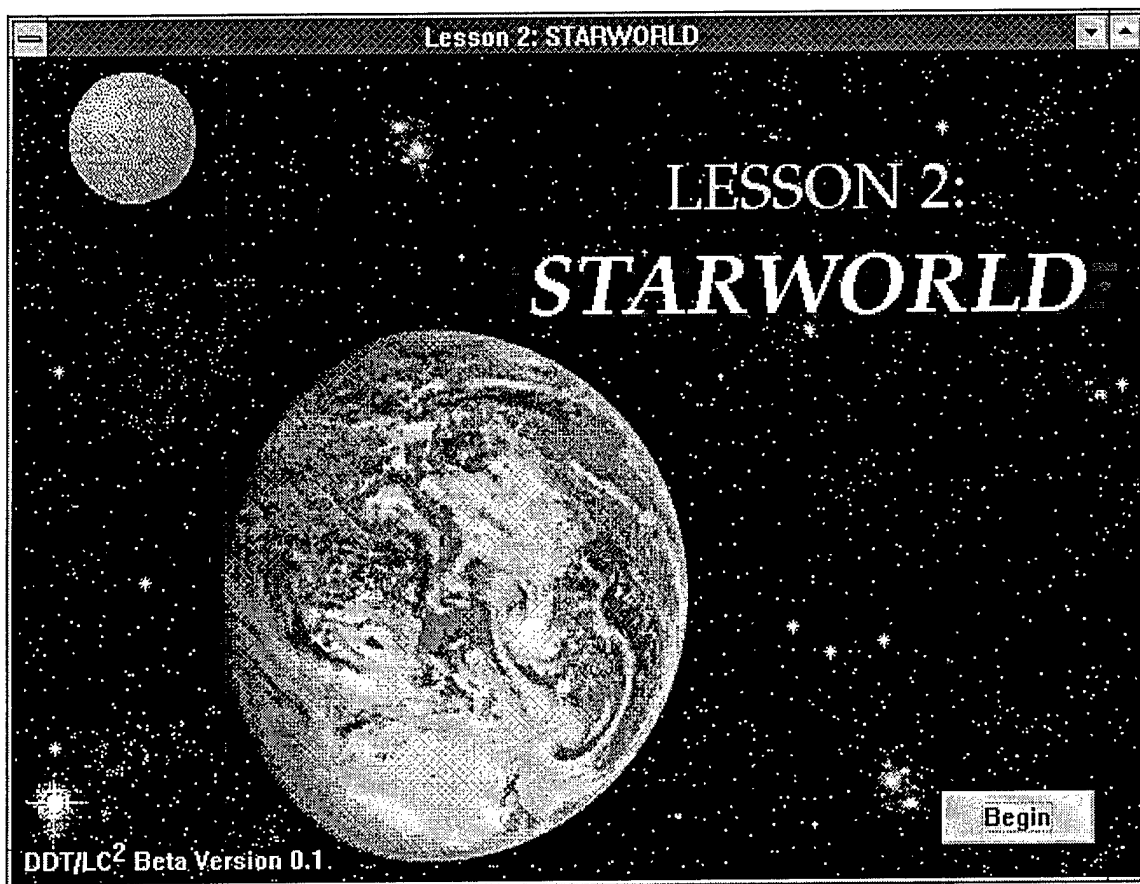
While these design steps were being performed, development began on the user interface for the lessons. This interface was designed to permit changes in the sequence of instructional elements, changes in the amount of control that learners would have over that sequence, and the systematic inclusion or exclusion of particular types of instructional elements. A basic version of this interface was developed using Toolbook (Version 1.53) software.

With the lesson interface in place, the specifications were transformed into working lessons. The lessons were then functionally refined and artistically embellished. The end product of lesson implementation was a modular structure of instructional elements connected by a modifiable script determining their sequencing constraints. The current script represents one possible micro-strategy for the lessons.

3.1.2. Taking a Lesson

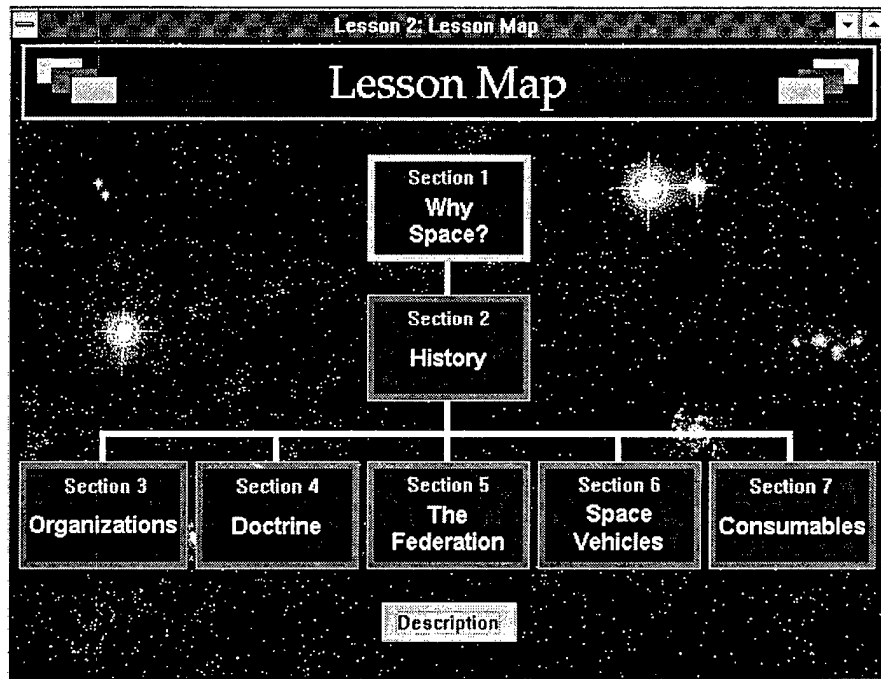
The modular structure, the user interface, and the "look and feel" of the lessons are illustrated in Figures 3-9. This sequence follows the process a student goes through when taking a lesson. In the DDT Beta Version 0.1, a user accesses a lesson from an icon in a program group. The lesson opens with lesson title screen such as the one shown in Figure 3.

Figure 3. Lesson title screen.



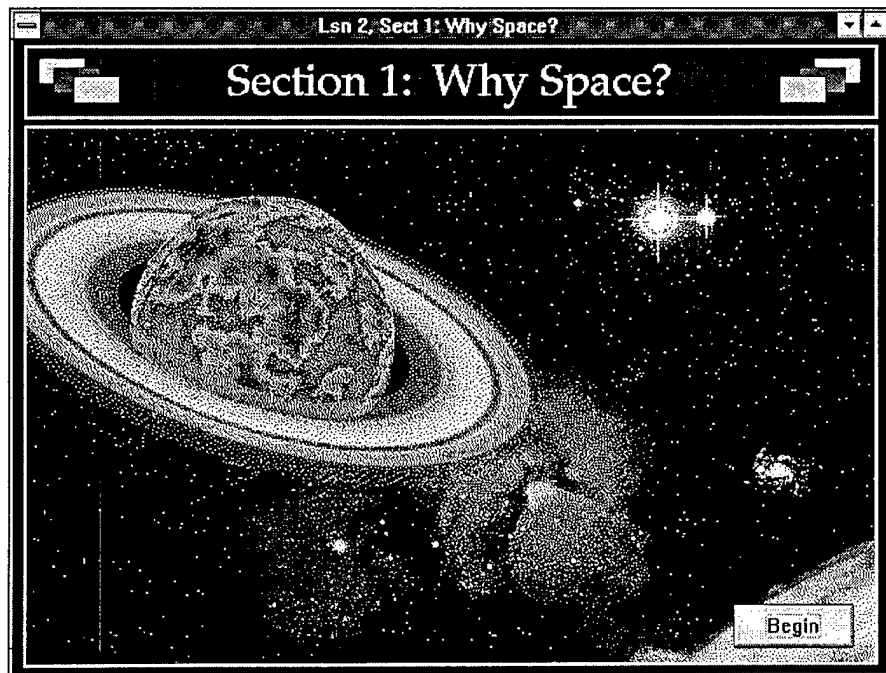
After clicking on the "Begin" button, the user sees a Lesson Map (Figure 4). The diagram in the lesson map shows the sections in a lesson. The hierarchical structure indicates prerequisite relationships. A color code indicates whether a section is accessible and its completion status.

Figure 4. The lesson map



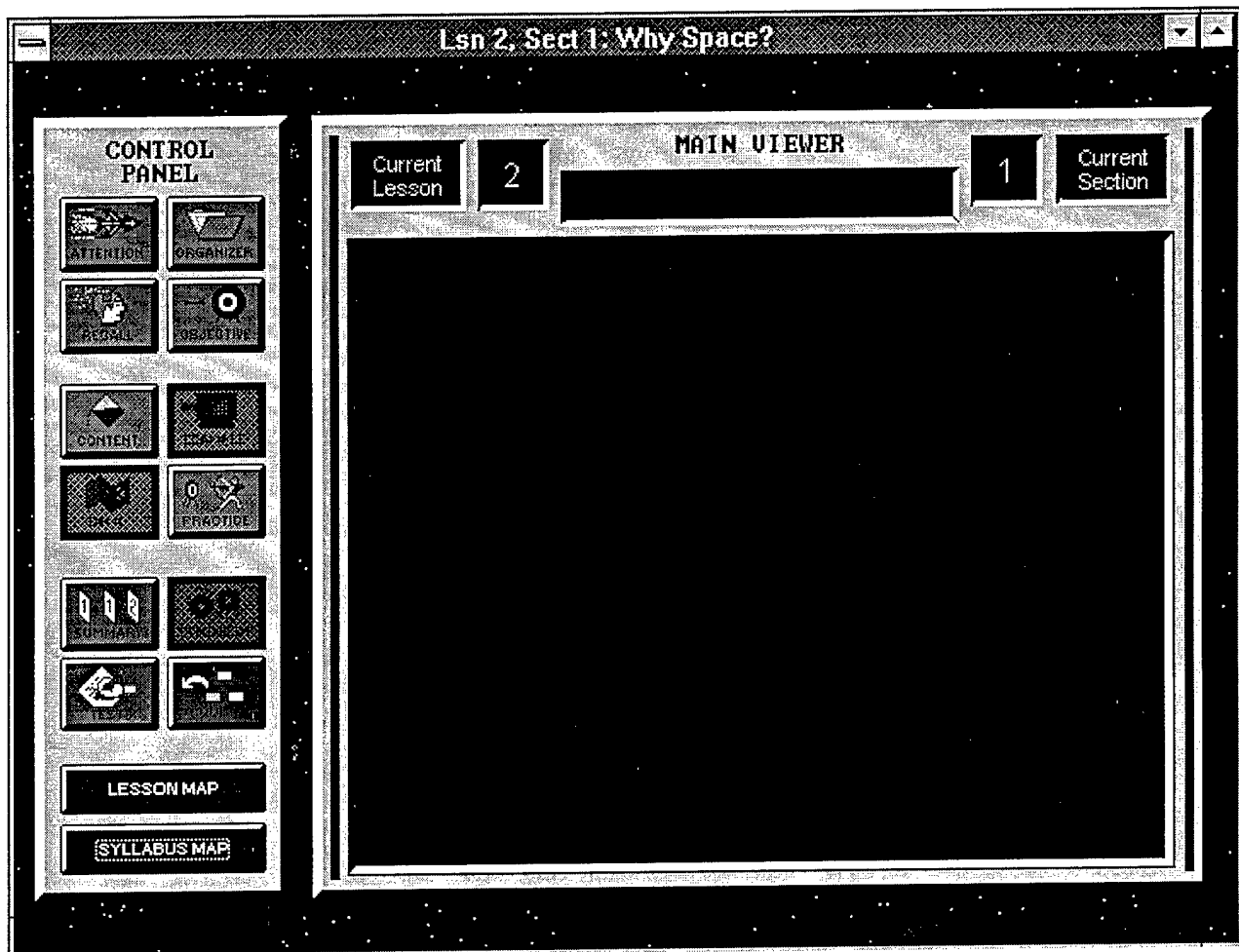
When the student clicks on an accessible section, the Section Title (Figure 5).

Figure 5. Section title screen.



After clicking on the "Begin" button of the Section Title Screen, the control and view screen for the instructional elements in a section appears (Figure 6). The instructional elements represent the lowest level of modularity in the lessons. Accessibility of elements is indicated by bright buttons on the control panel.

Figure 6. The control panel.



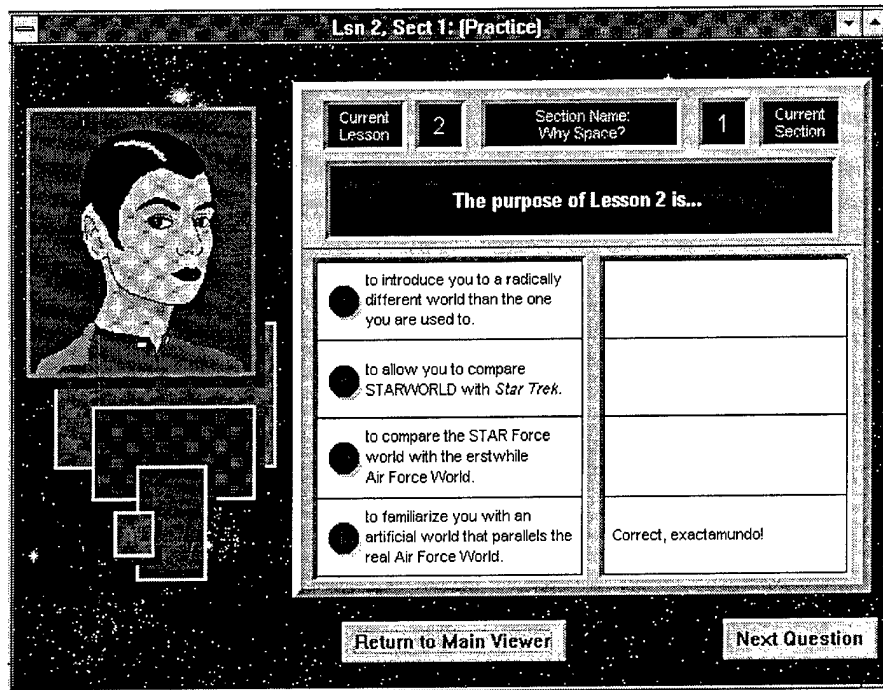
Clicking on a bright button on the control panel displays the corresponding element either on the Main Viewer or on a special panel. The element types labeled "ATTENTION", "ORGANIZER", "RECALL", "OBJECTIVE", "SUMMARIZER", and "SYNTHESIS", are usually displayed on the Main Viewer (Figure 7)

Figure 7. The main viewer



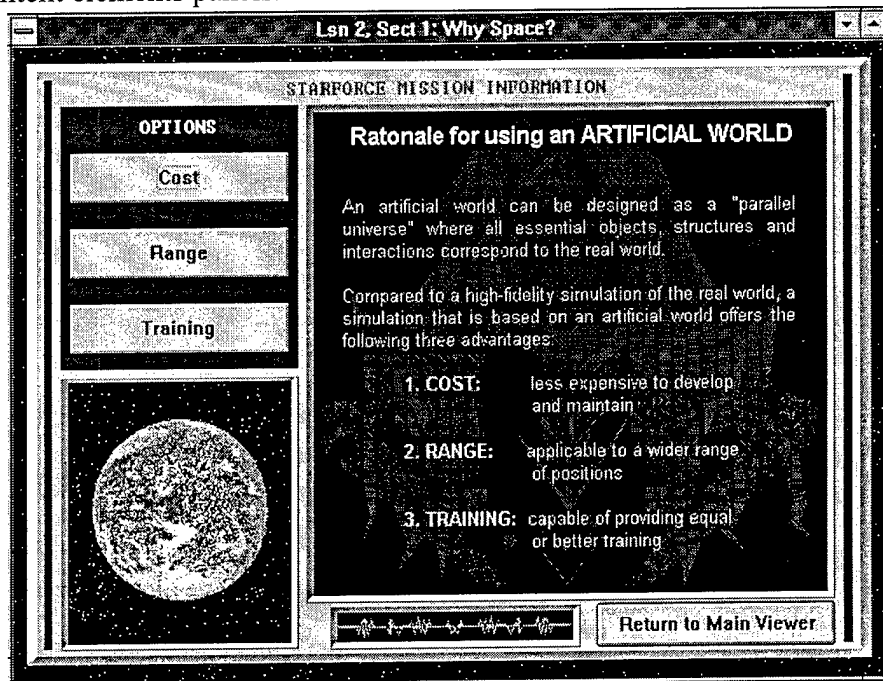
Element types labeled "CONTENT", "DEMO", "EXAMPLE", "PRACTICE", and "TEST" are displayed on special panels, such as the practice item (Figure 8).

Figure 8. Practice and test elements panels.



Content elements often include several "pages" worth of information. As such, the first display will provide an overview (Figure 9). Lower levels of information can then be accessed from there by means of control buttons on the left.

Figure 9. Content elements panels.



3.2. EXERCISE IMPLEMENTATION

3.2.1. Exercise Design Issues

As previously indicated, a number of design issues had to be resolved in the course of developing the exercises. The two most significant issues; namely, the problems of simulating causes and simulating time are discussed below. These issues were significant from the viewpoint of both software design and instructional design.

3.2.1.1. The Problem of Simulating Causes

Discussions with subject matter experts (SME) first led to a suspicion and later to confirmation that solutions to logistical problems depend to a very large degree on the cause or causes of the problem. For example, an operational unit may suddenly be faced with a severe shortage of food supplies. If this problem is caused by local enemy action, then the necessary and sufficient solution is speedy resupply. If this problem is caused by discovery of contamination, speedy resupply is still a necessary solution, but certainly not a sufficient one. In this case it is likely the problem is more global than local. Any particular shortage can have a number of different causes.

It is relatively easy to generate a shortage in a simulation, but it is quite a different task to simulate the array of potential causes and generate throughout the system, information traces that indicate a particular cause. At the same time, it is essential that a decision training system be capable of presenting widely varying problem sets that representative of the variability in the decision domain. The challenge of generating appropriate problems is further complicated by the need to control the complexity and uncertainty levels of practice problems in training systems.

3.2.1.2. The Case Approach

The problem of simulating causes led to a significant shift in the design of the simulation. The Phase 1 design was based on the assumption that the simulation could generate the practice problems based on outputs obtained from a relatively simple conflict model. Once we were certain that problem causes were indeed significant decision determinants, we were also certain that the "automated case generation" paradigm was not feasible. The solution was to shift to authored cases.

As illustrated in Figure 10, a case consists of two main elements: (1) the causal story, and (2) logistics simulation changes. The story provides explanatory information about why certain logistics events (e.g., shortages, consumption increases, etc.) have occurred. The details of the story influence how the student is expected to react to the problem. The elements that make up the story are structured to allow the student to "discover" the story and to permit evaluation of the student's discovery process. Logistics simulation changes are a description of the changes that need to be made to the logistics simulation to "cause" the logistics event associated with the case.

The causal story (Figure 11) consists of messages and information deposits. Messages, like mail, are unsolicited information. They arrive at the message desk during the course of a decision making episode (DME); the student can: (a) open the message and view their contents; (b) file for later action; or (c) dispose of them.

Figure 10. DDT's case approach.

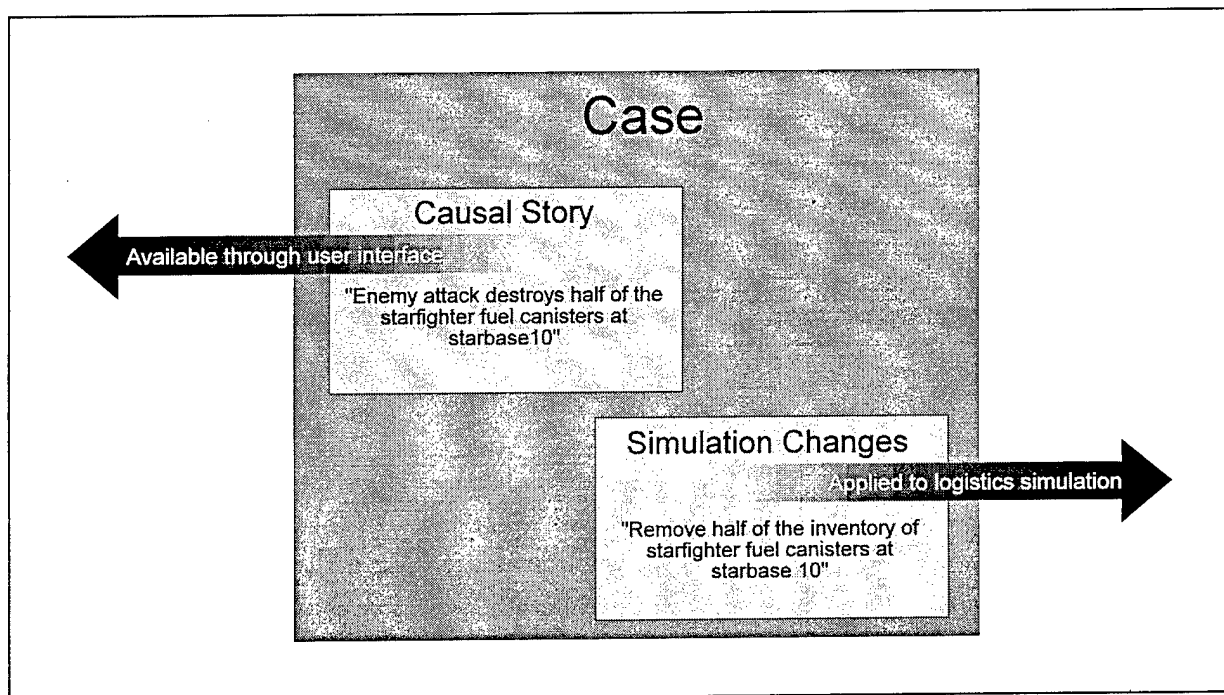
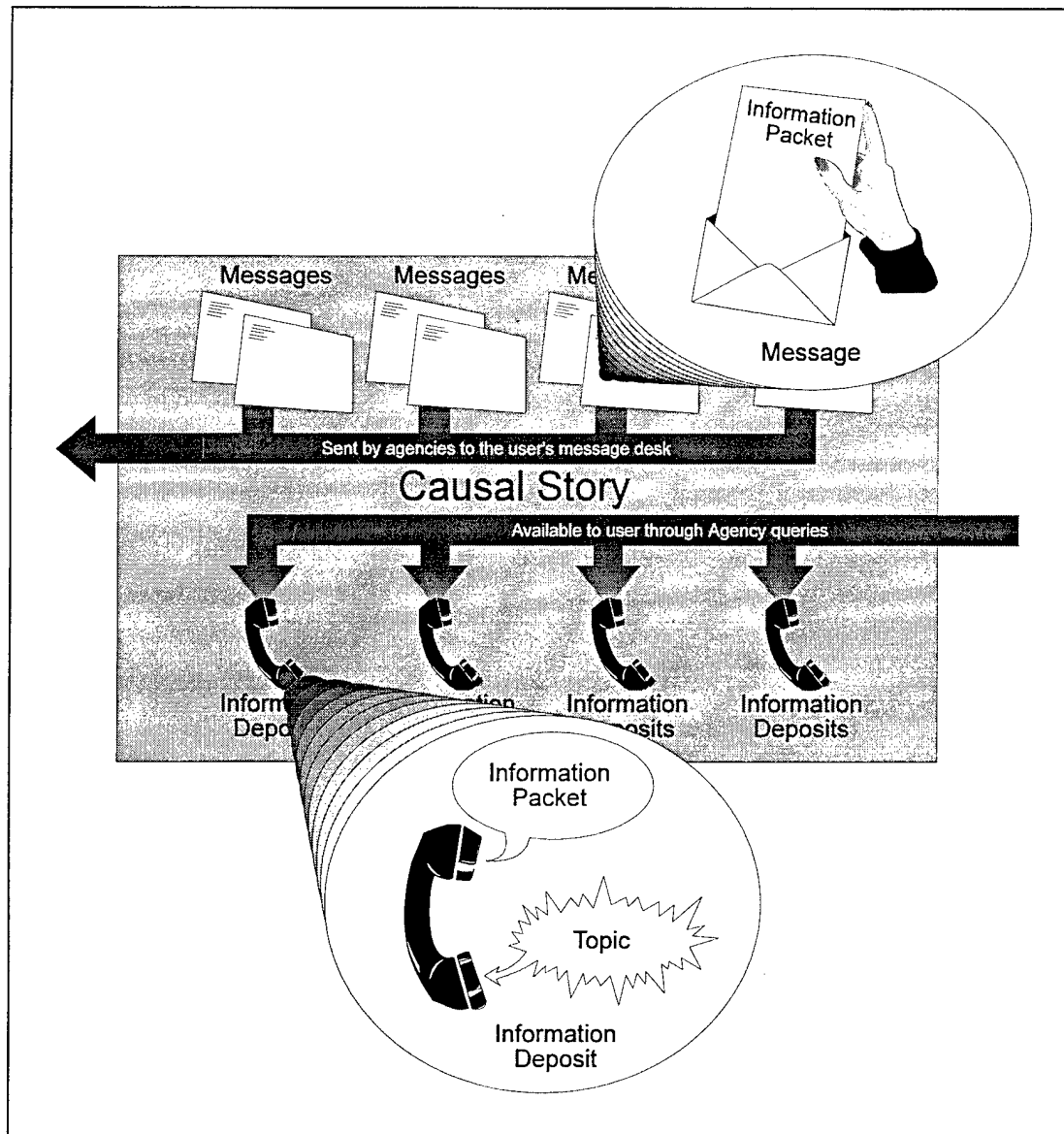


Figure 11. The causal story.



Information deposits are solicited communications. The student must explicitly query an agency to get the information contained in an information deposit. Each information deposit is associated with a responding agency and an eliciting topic and contains information that is presented when the student asks the agency about that topic. A topic is a word or a short phrase that can serve as the object of a student's query of an agency. This word or phrase will have appeared in some information previously viewed by the student. As illustrated in Figure 11, messages and information deposits communicate their information using an information packet. An information packet is the smallest element of information and contains the actual text or pictures that present the information to the student.

Logistics simulation changes are a description of the changes that need to be made to the logistics simulation to "cause" the logistics event associated with a case. There are five different types of logistics simulations changes: (a) adding/removing resources; (b) tagging resources; (c) adjusting consumption rates; and (d) adjusting supply rates.

Adding/Removing Resources. Resources can be added to the simulation. Adding resources might be necessary to give the student specific options for correcting a shortage. Resources can also be removed from the simulation. If commodities are removed, that will cause a possible one-time shortage. If transportation resources are removed, that will cause a possible supply rate problem.

Tagging Resources. Resources can be tagged with information that relates both to the story and to the resources' behavior in the simulation. For example, food kits might be marked as contaminated and not available for consumption. This would cause a shortage of food kits. The food kits, however, would appear normal if the student formulated a query about food kits. Only when the student asked about an appropriate topic would the information about the contaminated food kits be revealed.

Adjusting Consumption Rates. Consumption rates can be adjusted. An increase in consumption at a particular agency will cause a shortfall if the student does not adjust the appropriate shipment schedules.

Adjusting Supply Rates. Supply rates can be changed. An decrease in supply from a particular agency will cause a shortfall if the student does not adjust other supply rates or adjust shipment schedules.

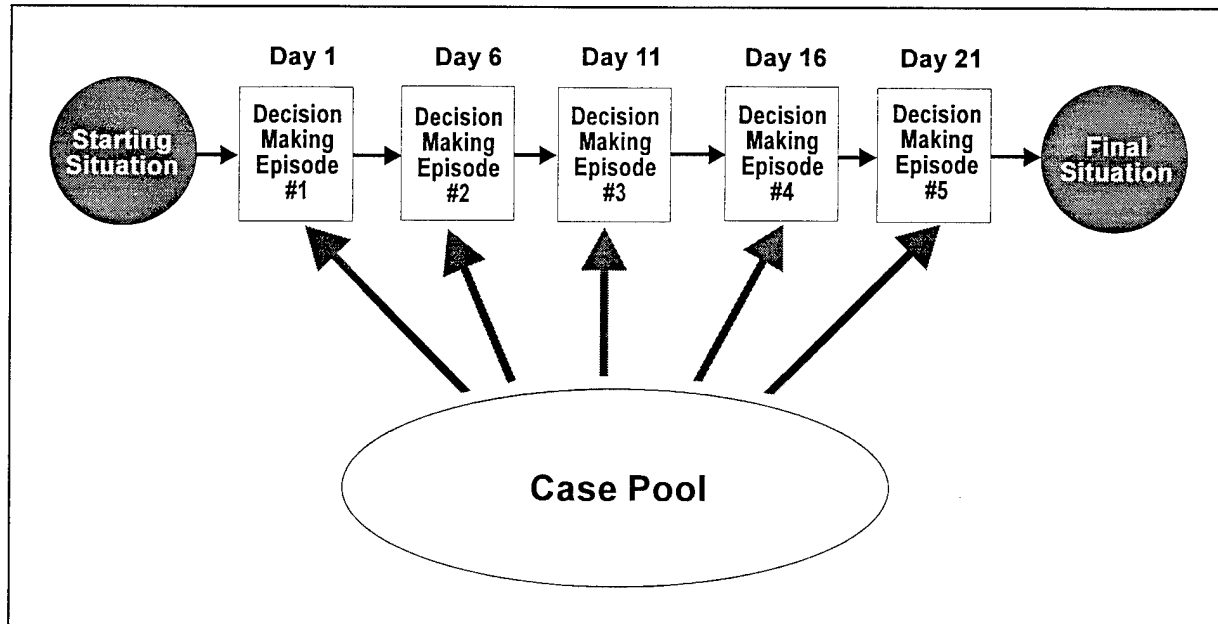
3.2.1.3. The Problem of Simulating Time

A second problem was presented by the duration of logistical decision making tasks in the real world. The time from task recognition to decision implementation may be very short; however, the time from implementation to the appearance of results is usually measured in days. Results from a logistics action represent "natural" feedback information to the decision maker. This natural feedback is extremely desirable and important for training. However, it would be impractical to have a student wait for days for feedback to maintain time profile correspondence between real and training tasks. During training, the student should receive feedback on the results of their decisions within minutes. The challenge then, was to provide natural feedback within minutes while clearly indicating that these minutes represent days on the real time scale.

3.2.1.4. The DME Approach

The solution to simulating time in DDT Beta Version 0.1 was based on the notion of "pulling shifts" in a Logistics Readiness Center (LRC) (see Figure 12). Each shift is represented by a Decision Making Episode (DME) in the exercise.

Figure 12. Decision-making episodes.



The student attends a series of shifts that are days apart in scenario but only minutes apart as DME's in actual training time. The student implements decisions in one DME and the simulation proceeds in "fast forward" mode to the next DME. The next DME occurs a certain number of days later, but only minutes of real time will have passed. The time interval between shifts was set at five days to allow sufficient time for supplies to travel from source to destination (i.e. to allow sufficient time for the appearance of decision results). These results can currently be accessed by the student by means of a query facility. In subsequent versions of the system, the student will receive an update briefing at the beginning of each new DME/shift.

3.2.2. Making Decisions in an Exercise

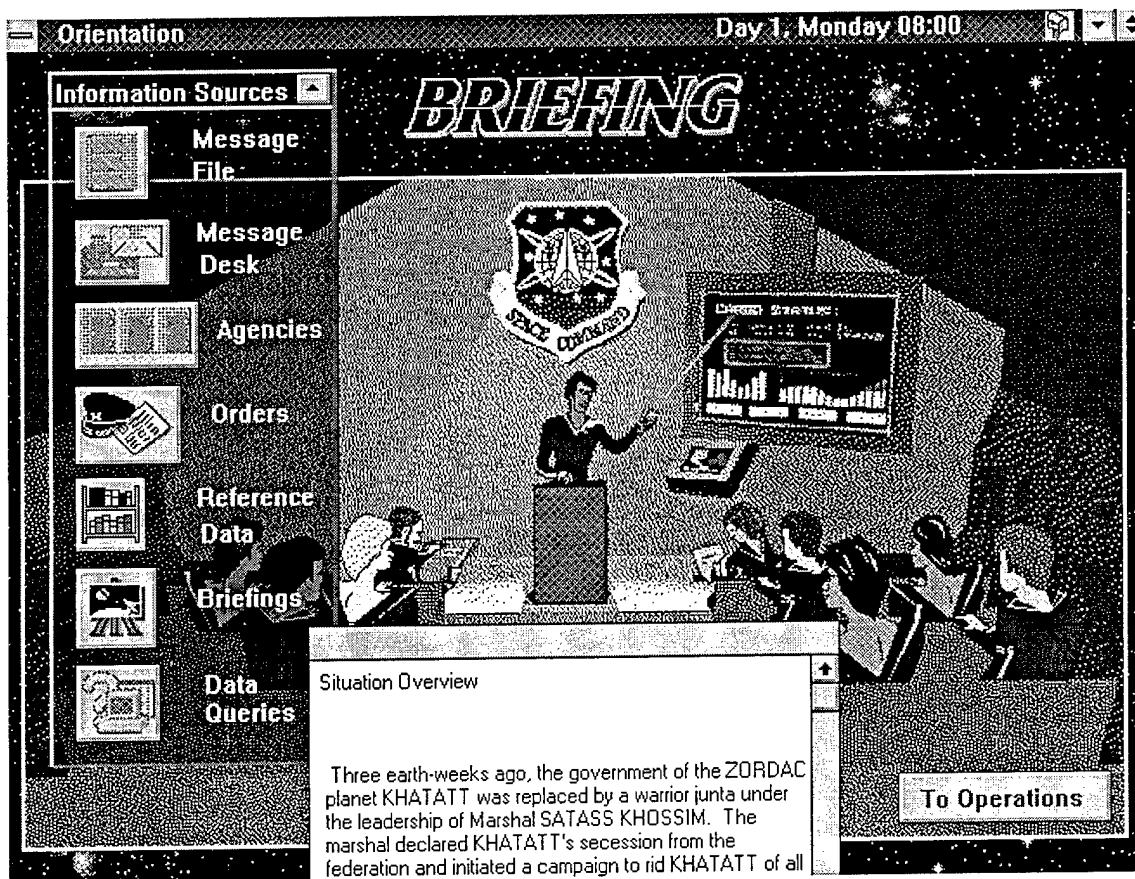
Exercises provide decision making practice in an artificial simulation environment called STARWORLD. Each exercise rolls off in three phases. The first phase, called Orientation Phase or Briefings, provides the student with a opportunity to become familiar with the starting

situation for the exercise scenario. The "war" starts and the clock begins to tick when the student enters the second phase, called the Operations Phase. During this phase the student does duty over several shifts in an LC2 node that represents an LRC. During each shift (or DME) the student is exposed to several decision-making problems. After the last shift of an exercise, the student enters the third phase of an exercise: the Debriefing Phase. During the final phase, the student has an opportunity to review a number of performance scores and the final supply status at the operational unit(s) for which they were responsible. Each of these three phases is described in more detail below.

3.2.2.1. The Orientation Phase

Familiarization with the starting situation of an exercise is enabled by three Information Sources: Briefings, Orders, and References (Figure 13).

Figure 13. The Orientation Phase



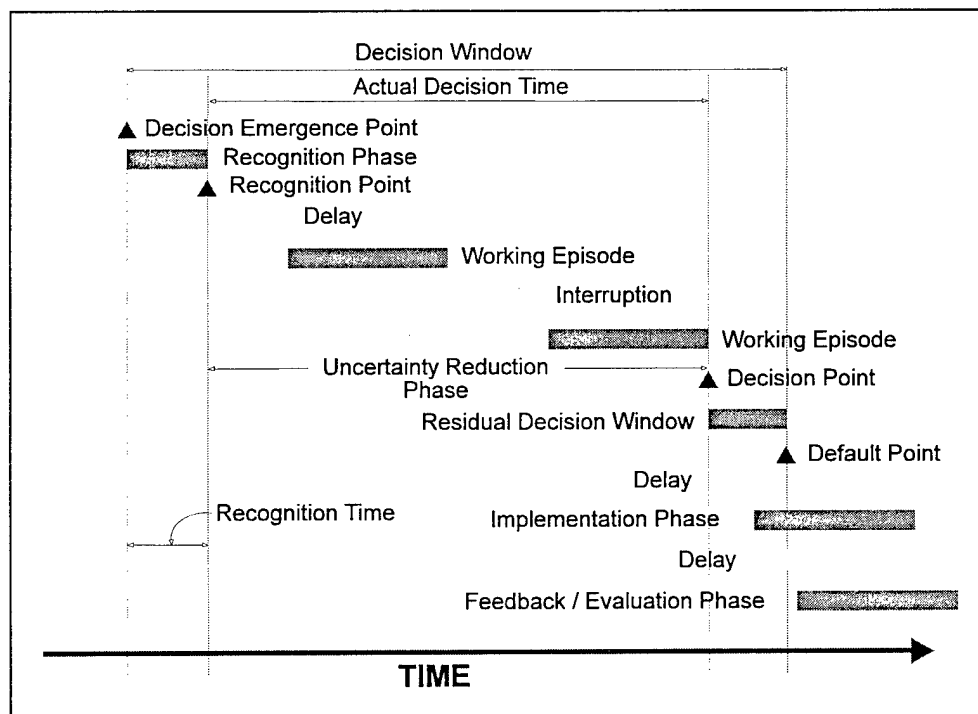
Briefings and orders are structured to resemble typical military situation briefings and daily orders. They characterize the general military situation and provide several special

sections, one of which deals with logistics. The Briefings and/or Orders refer to objects in the artificial STARWORLD in which the scenario takes place. The student may want to refresh their memory about one or more of these objects before proceeding with the Operations phase. To do so, they will be able to access the References in future implementations of the system.

3.2.2.2. The Operations Phase

This phase provides the actual practice opportunities for decision making. As indicated before, such opportunities are provided during DME's that represent shifts in an LRC. One or more problems (also called "cases") can be scheduled for each DME. The subsequent paragraphs describe how decision making practice is implemented in the current system version by "walking" through a case from beginning to end. The description is organized in terms of the Timeline Model developed during Phase 1 of this project (Figure 14). The model is subdivided into four parts or processes: Recognition, Uncertainty Reduction and Option Editing, Implementation, and Feedback.

Figure 14. The timeline model.

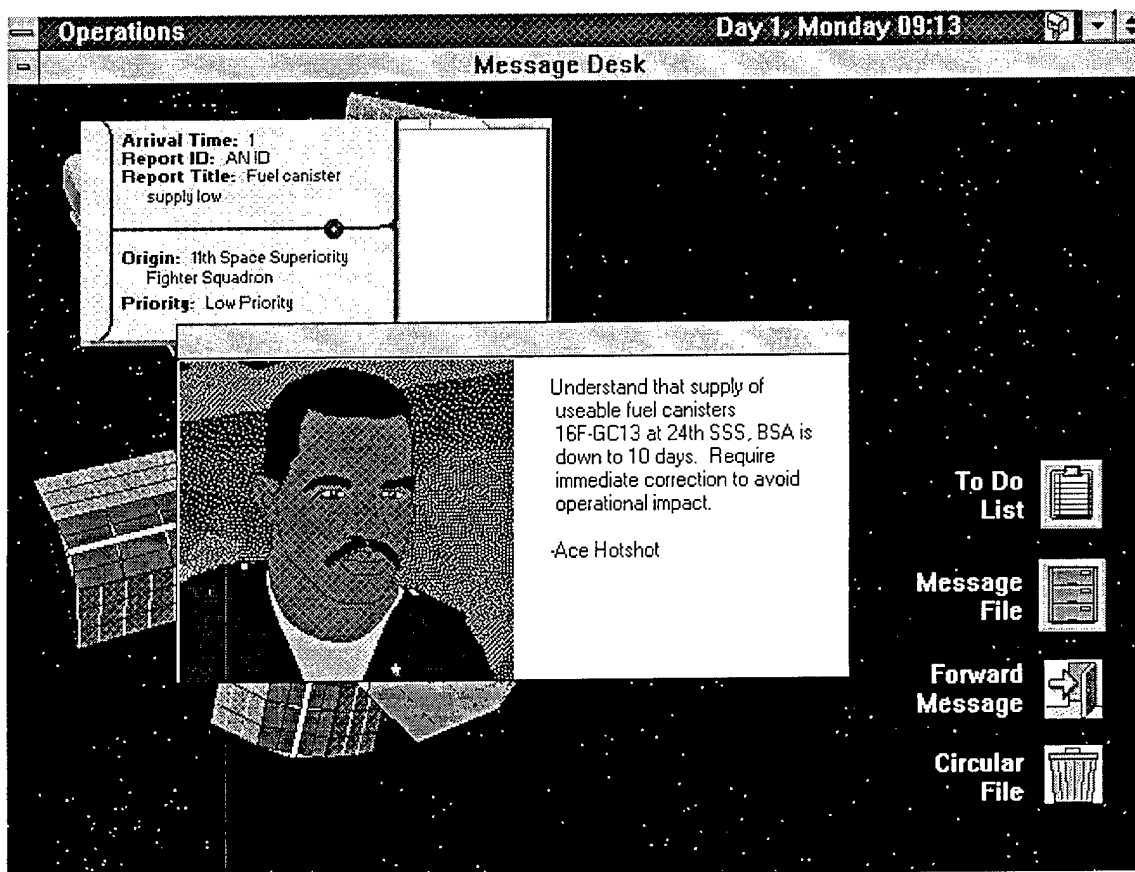


A major consideration in the implementation of decision making practice was fidelity to the actual decision making tasks faced by personnel in LC2. At the same time the implementation had to be controllable in terms of the theoretical constructs developed during

Phase 1 of the project. Of particular concern in this respect was the ability to control the type and relative amount of uncertainty presented by any particular case.

Recognition. During the recognition, process the student's task is to recognize the existence of a decision problem to be dealt with. Recognition is based on information that is either supplied by the system or solicited by the student. Information supplied by the system arrives in the form of one or more messages on the Message Desk. These messages are either genuine alerts to problems the student is expected to recognize or they are distracter messages. Either type of message can be ambiguously worded thus making it difficult to distinguish genuine alerts from distracters. Figure 15 illustrates an example of how such messages are presented and worded.

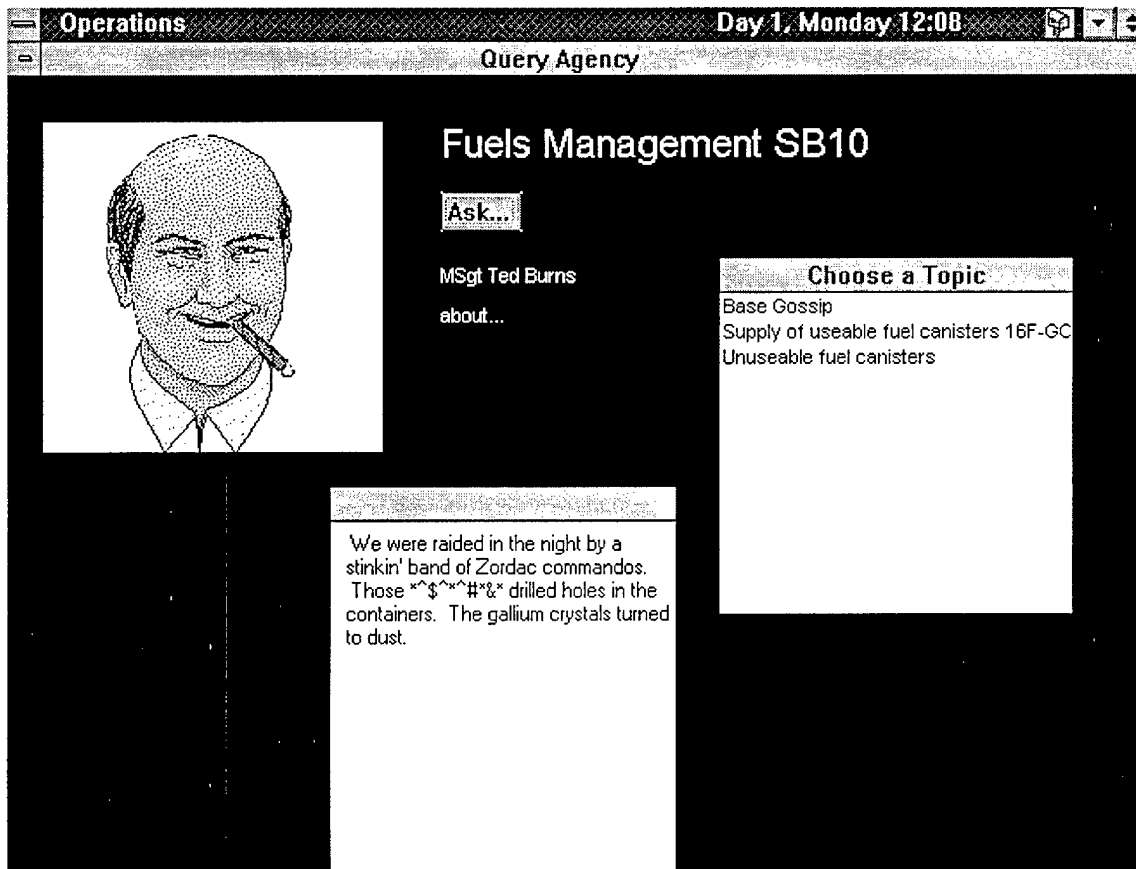
Figure 15. Sample message.



To clarify whether a message hints at a real problem or not, the student must reduce situation uncertainty. This is accomplished by soliciting information from the various agencies participating in the scenario. These agencies either know something about a topic mentioned in a

previously seen message or not. If they do, they provide additional, more or less clarifying, information. Figure 16 illustrates the result of querying an agency that has further information about a topic.

Figure 16. Sample information from agencies.

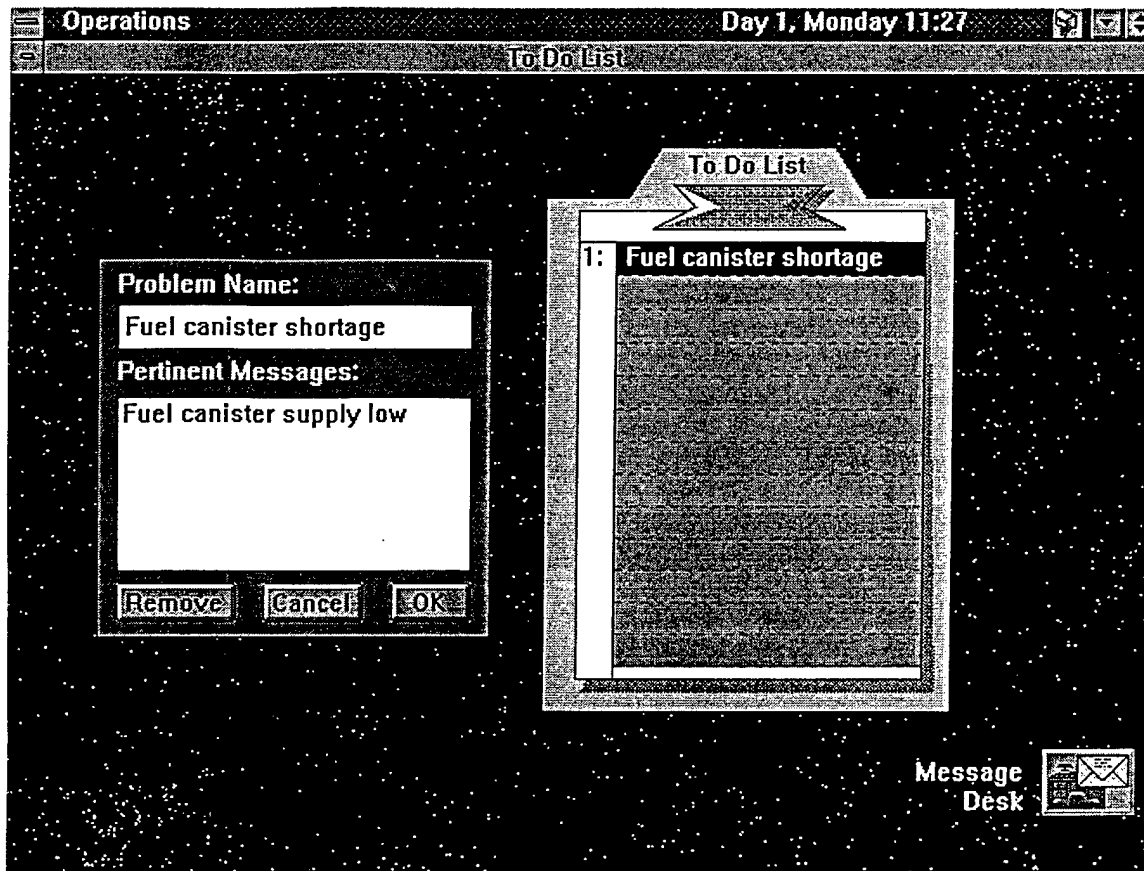


The student's uncertainty reduction efforts are more or less efficient depending on how many queries are made to recognize the existence of a genuine problem. Efforts are effective to the degree that the student discovers all the pieces of information deposited with agencies that are expected to know something about the problem presented in the case.

Once the student discovers there is a problem to be dealt with, they can put it on his agenda for problem solving. For this purpose the system provides a To-Do List. If the student discovers that a message is a distracter, they can either file it away for later reference, pass it on to other agencies, or throw it away. To deal with a message in any of these ways the student simply drags the message over to the respective icon (see Figure 17). To put a recognized problem actually on the To-Do list, the To-Do List window, shown in Figure 17 has to be

brought up by a double-click on the icon. In that window a mechanism is provided to enter the problem on the list and to name it. If the list already contains problem names, the student can adjust their order and thus assign relative priorities.

Figure 17. The to-do list window.



Once the student has accomplished all that, the system assumes the problem is recognized and marks the minutes of playtime that have passed since the presentation of the first message hinting at the existence of a problem.

Uncertainty Reduction and Option Editing. Problems on the To-Do List must be dealt with. Dealing with a problem means, in the most general sense, correcting some deficiency at some operational unit. To correct a deficiency, the student must set a goal and determine a means to achieve that goal. The basic means to achieve goals are sourcing and transportation (i.e., the student must find appropriate sources for the needed commodities and appropriate means of transporting them to where they are needed). Since many different combinations of sourcing and transportation are possible, the student must reduce goal uncertainty and option

uncertainty and then reach a decision to implement an option. Two facilities are provided for these purposes: the Data Queries and the Decision Options window.

The Data Queries simulate access to computer data bases. The current implementation allows the student access to four types of queries: Consumables (type, location, owner, number), Transport Schedules (what missions travel between any two points, how much free capacity do they have on average), Shipments (source and destination for any consumable shipment, next shipment departure), and Shipment Schedules (source and destination for any consumable shipment, next shipment departure, frequency of shipments). The student can thus reduce uncertainty with respect to sourcing and transportation by means of the data query facilities. One example (Consumables) of a Data Query window is shown in Figure 18.

Figure 18. Data query window.

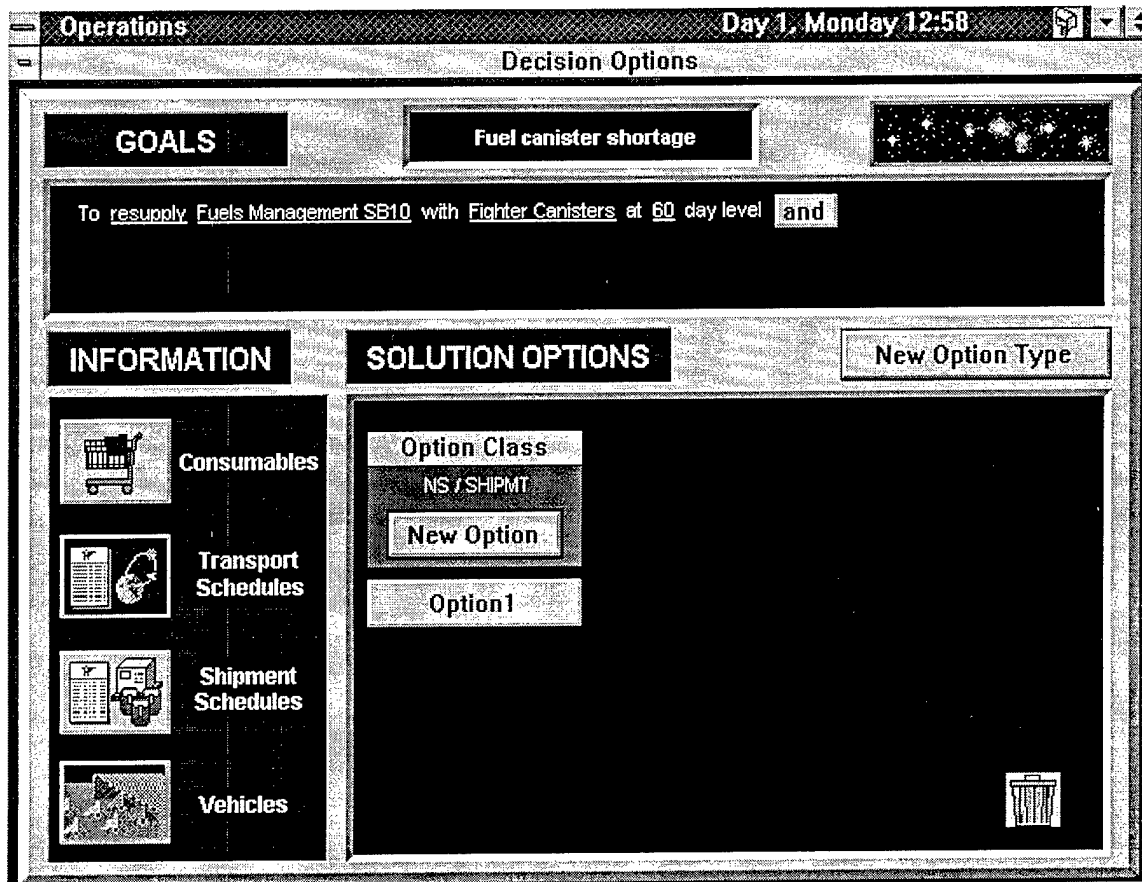
Consumable	Owner	Location	Number	Creation Date	Manufacturer
Fighter Canisters	Star Depot SLC 52	Unadilla	100	Day 1, Monday 08:00	ACME Supplies
Fighter Canisters	Base Supply Agency SB10	StarBase10	900	Day 1, Monday 08:00	B&D Supply
Fighter Canisters	Star Depot SLC 52	Unadilla	30000	Day 1, Monday 08:00	B&D Supply
Fighter Canisters	Star Depot SLC 11	Provo	6000	Day 1, Monday 08:00	B&D Supply

Owner	Location	Consumable
11th Space Superiority Fighter Squadron	Albany	Burn Shields
12th Planet Attack Squadron	Abuquerque	Buster Bombs
13th Intelligence and C3 Squadron	Edin SFB	D Charges
14th Starbase Support Squadron	Edin SFB	Exo-cans
1st Intervention Wing	Edin SFB	
21st Space Superiority Fighter Squadron	Edin SFB	Food Kits
21st Beamer Squadron	Edin SFB	Fuel Cakes
22nd Planet Attack Squadron	Lake SFB	Fuel Pellets
22nd Short Haul Squadron	Lake SFB	Fun Kits
23rd Intelligence And C2 Squadron	Lake SFB	Long Range PT's

The Decision Options window pictured in Figure 19 allows the student to set a goal, pick an option class from a menu, and define specific options. Goals are articulated as sentences. The

mechanism is a series of drop-down menus. Up to two goals can be specified in the current version.

Figure 19. The decision options window.



Once a goal is specified, option classes can be selected from a drop-down menu of six classes that encompass all general means to achieve correction of a deficiency. Up to three option classes can be accommodated in the window. Congruence between a goal and the chosen option class is not evaluated in the current system version. Once the student has chosen an option class, he/she can define up to three options that specify in detail how that option class is to be instantiated. The current system version does not check congruence between specific options and option class.

Specific options are articulated as new shipments, changes to shipment schedules, new transportation missions, or changes to transportation missions. Any specific option can contain one or more of any of these elements. Figure 20 illustrates a fully specified new shipment. This

shipment can, and in this case actually does, represent the only element in an option (i.e., it is a full specification of the option).

Figure 20. Shipment option window.

Shipment					
Commodity		Source		Recipient	
Fighter Canisters		Star Depot SLC 52		Fuels Management SB10	
From		To		Freight Mission	
1.	Unadilla	Warner Robins		RunRover1: Unadilla, Unadilla, Rover	
2.	Warner Robins	Luna		FlyShorty1: Warner Robins, Warner Robins, Shorty	
3.	Luna	Herpes		Warp1: Luna, Luna, Milofant	
4.	Herpes	StarBase10		FlyShorty2: Herpes, Herpes, Shorty	
5.	StarBase10				
Quantity		Shipping Date			
5000		24			
				OK	Cancel

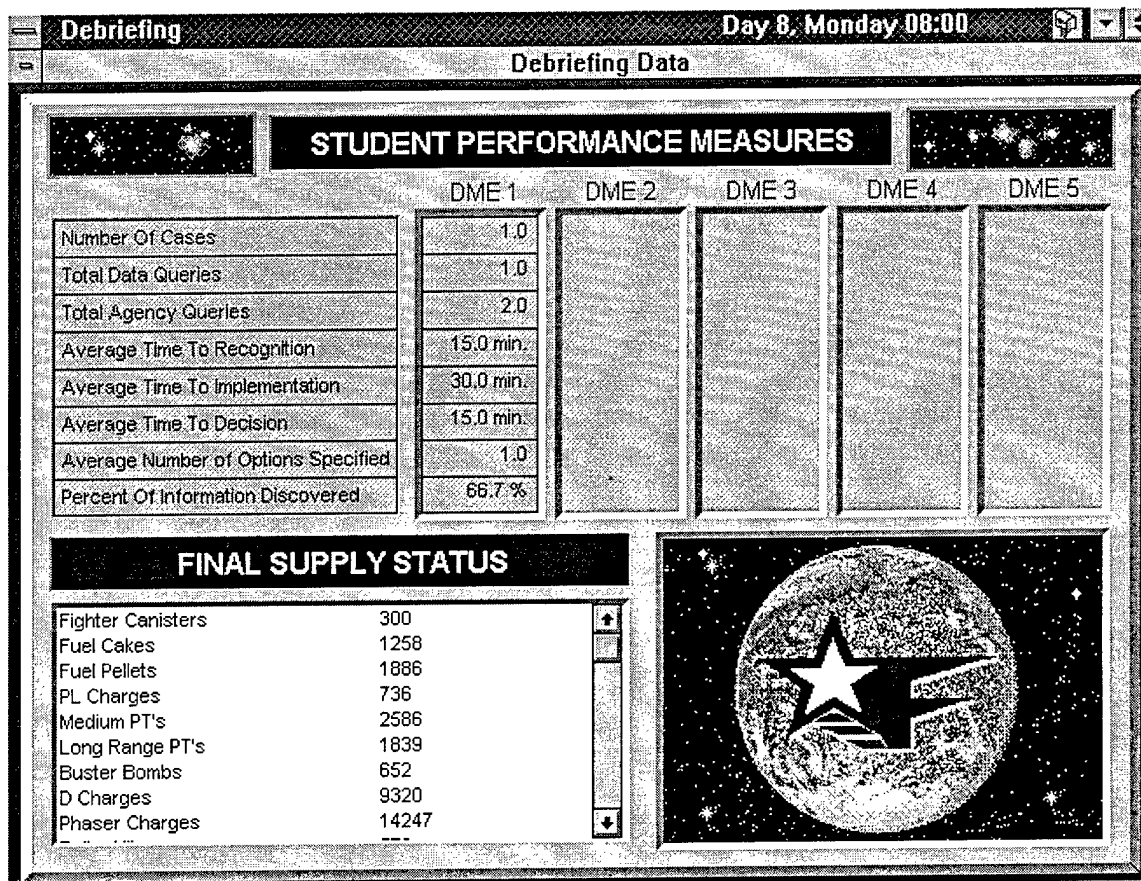
Implementation. The student can work on goals, option classes and specific options as little or as much as he/she wants. For implementation, a minimum of one articulated goal, one option class, and one fully specified option is required. The act of implementation is very simple: The option the student has decided on is selected and an "Implement" button is clicked. If the option is physically feasible, it is implemented by the system; otherwise, error messages direct the student to correct incomplete or incorrect specifications.

Feedback. The system currently does not provide immediate, "artificial" feedback on implemented or contemplated options. Natural feedback is available by accessing data queries during the next DME. The data queries produce tabular displays that show how consumables have moved through the scenario since the last DME. These displays are not easy to decipher. Natural feedback will therefore take the form of Update Briefings in subsequent system versions.

3.2.2.3. The Debriefing Phase

The Debriefing Phase provides delayed artificial and natural feedback on the entire exercise as depicted in Figure 21.

Figure 21. The debriefing.



Artificial feedback consists of a variety of performance scores that summarize performance for each DME (see upper half of Figure 21). Performance for individual decision problems can be seen only if but one problem was scheduled for a DME. Below these performance scores is a table showing the final supply status at the units the student had to take care of. This status information is seen as natural feedback, since it would be available "naturally" in an exercise or operational situation.

IV. SUMMARY

During Phase 2, a decision-making training prototype was developed. This prototype is more than a mere demonstration of the user interface. It is a fully functional, albeit not exhaustively tested, prototype of the core components of the training system this project aims to develop. The prototype consists of two full lessons and one simulation exercise. The latter consists of a simulation engine, a user interface, and a scenario, and is implemented with more than 40,000 lines of code. The two Toolbook lessons consist of a total of 243 pages. The full prototype system occupies four high-density disks. The system thus represents a significant amount of work in quantitative terms.

The quality of the work that has been accomplished must be viewed from two points of view. One point of view is the graphic look and feel. Considerable care has been taken to give the system a finished, professional, and appealing look. As successful as this effort has been, this quality issue is the less important of the two. More significant is the quality of the system in terms of its congruence with the theoretical background and its fidelity to the decision making tasks that LC² personnel have to perform in the real world. It is fair to say that the system's congruence with theory is nearly exact. However, it is equally fair to say that task fidelity is at this point not yet where it ought to be. It is clear that the achievement of the desired level of task fidelity would require an evolutionary process that is fed by feedback from SME's who have the opportunity to work with the prototype. This is the primary reason why the development of the prototype has been pushed as far as it has been during Phase 2. We now have two years before the scheduled end of the project, the vehicle to solicit SME feedback and thus to engage in that planned evolutionary process.

While the key instructional and software implementation issues have been solved at this point, much remains to be done. Over the past year, particularly during the final months when the system began to be working as a whole, we have discovered many opportunities for the improvement of the system. It is doubtful that many of these ideas and opportunities could have been discovered without taking prototype development as far as it has gone in this phase. As this project passes its midpoint in time and transitions from Phase 2 to the final Phase 3, it is imperative that Phase 3 be started with a thoughtful review of these improvement opportunities as they relate to the available resources and the project's ultimate goals.

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